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OUTLINES OF NATURE STUDIES.

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TO THE TEACHER.

This Bulletin is published for you (not for the children), with the hope that it may help you in your own studies of Nature. It is not intended that you deal with all of the studies outlined in the bulletin, as the subjects are purposely given a wide range to meet the needs and aptitudes of teachers as a professional body. The questions are for *you* to answer as you investigate each problem presented. When you are familiar with the problem you will, if you are a good teacher, frame other and better questions for your pupils.

Nature-Study from your view-point as a teacher is *Natural Study*, a *method* or means of developing mental power in the pupil under the careful guidance of the teacher, by encouraging close observation of the things of Nature which lie about him, and by begetting an attitude of inquiry into their meaning so that the truth is discovered through the exercise of the pupil's own self-activities.

It is quite true that there are other values in Nature-Study, but they are secondary, viewed from a pedagogical standpoint. With many persons the acquisition of information about the things of Nature by a study of Nature is the chief aim; while with others the development of a sympathy with, and an interest in the common things that surround them, is the only value in its sudy. These secondary values are very great, but they can be realized as a matter of course by making method the chief aim of Nature-Study. Now we have Sympathy, Information, and Method, but the greatest of these is Method.

It is your duty, as a teacher, to develop this method of study among your scholars. You should know the mental characteristics of every child in your school, if you are to get the best results. You should also have a fair knowledge of the subject which you are asking the children to investigate, else your probing, sustaining, question, and your direction of the children's work will soon cease. The great needs of the teacher at the present juncture are *knowledge of the subject-matter*, and a *correct meaning of the Nature-Study Method.*

WHAT SUBJECT TO TAKE UP FIRST ?

Whatever has an interest for the children, whatever has an interest for you, or whatever is suggested by a reading lesson. Once you *begin* you will be surprised at the number of subjects which come up for investigation,—but *be sure to begin.*

HOW TO MAKE THE STUDY EFFECTIVE ?

1. Whenever possible, make it the basis for (a) *oral expression* (extempore addresses); (b) *written expression* (reports and composition); (c) *form expression* (drawing and modeling); (d) *color expression* (painting).

2. As far as possible correlate it with the other school studies, which will frequently be vitalised and refreshed by the correlation.

3. Encourage the making of collections of natural objects, and have school exhibitions at intervals.

4. Have boxes and cages for such live animals as toad, snake, rabbit, or crow, and flower-boxes for plants near the window.

5. Encourage the children to keep a diary of things seen outside of school, such as first flowers, first birds, first frost, first snow-fall, etc., etc. A school diary should also be kept, in which the children may make entries. (Nature-Study Journal).

6. Keep a school-garden. Get help if necessary from a neighbor, but keep a garden. By its means many problems can here be worked out in a concrete form. Have a school exhibit at the close of the season.

7. Give practice in *sight seeing*, or in reporting *Voyages of Discovery.*

8. Finally, try and read some of the most excellent books on Nature-Study which have been recently published. Get some of the best every year for your school library.

The new prescribed course in Nature-Study for Public Schools is quite explicit as to the scope of the work to be done in each Form, but it must be noted that much latitude is given the teacher as to the subjects and mode of treatment. This is as it should be, for Nature-Study cannot be taught by a machine. It stands for independence and the full expression of the personality of the teacher. It stands also for the active pupil and the suggesting teacher.

OUTLINES OF NATURE STUDIES.

THE TERRARIUM.

A terrarium is easily made from an old berry crate or soap-box; it should contain three inches of good rich soil and the open sides covered with netting. Sod with lawn grass will do admirably. Other plants, such as thistles, clover, cabbage, etc., should also find a place in it. There should be a mossy corner where shy creatures may hide. The terrarium is of great value in Nature-Study for in it can be kept many creatures, such as caterpillars, crickets, grasshoppers and locusts, toads, and salamanders, and many others. It is then possible to study their habits at close range. The secret of making full use of a terrarium is to imitate nature, and to make the conditions for the encaged creatures as natural as possible.

THE AQUARIUM.

See O. A. C. Bulletin 134, "Hints on Making Nature Collections," page 7 on the making of an aquarium.

It requires a little experience and some experimenting to ascertain the right balance between the plants and animals of an aquarium. At the bottom there should be two or three inches of clean sand and a few stones. Only those animals and plants should be chosen which live in quiet water. When the balance is once established, but little attention is required beyond the addition of water. Every school should have an aquarium of some kind.

I. Plant Societies.

1. What is a plant society? Why do plants grow in societies?

2. What factors (ecological factors) determine the vegetation types by influencing their life and growth? What is a vegetation type? a flora?

3. Distinguish societies and colonies.

4. How do plants associate? Find examples.

5. Explain how societies may differ at different times of the year.

6. Name some common plant societies, and determine the main factor influencing the type.

7. Explain clearly: layers, zone, tension line, mesophyte, xerophyte, hydrophyte, and halophyte.

8. Discuss "Plant Migration" and "Distribution," the lines of stress, lines of migration, the causes of migration, the structural characters favoring migration.

9. Explain why autumnal coloration is so striking in American forests.

10. Determine the adaptations of the members of the different societies to their environment.

11. Make special studies of the plants of one or more of the following: (a) a swamp, (b) a pasture or meadow, (c) a roadside, (d) a thicket, (e) a woods, (f) a lawn, (g) a cliff, (h) a barnyard, (i) a sphagnum swamp or bog, (j) a pond, (k) rocks, (l) sand-dune, (m) a ravine, (n) a shore, (o) a dry hill-side.

Make (a) list of the species of plants growing in each society; (b) determine the relative abundance of each species; (c) locate the positions of each species, (d) and try to explain any adaptations.

12. Make diagrams of distribution of the plants in each area studied.

13. Observe and try to explain the adaptation in the following: (a) strengthening devices in the large leaves of milkweeds, basswood, and catalpa, (b) flat prostrate habit of many shrubs, (c) elastic stems of cereals, (d) hairy leaves of mullein, (e) colored buds, (f) underground fleshy roots and tubers, (g) "sleep" position of clover leaves, (h) rosette habit of dandelion, blueweed, and plantain, (i) thickened leaves of purslane.

14. Study the swamp-thicket society near your school.

[Consult Coulter and Atkinson.]

II. Flower Calendar.

Each student should keep a *Flower Calendar* for *Wild Flowers*.

Date.	Name of Flower.	Kind of Soil.	Shade or Sheltered.	Remarks.

The flowers are not to be picked, but rather studied in their wild haunts.

By examination of the earlier plants determine how they have developed so rapidly.

What advantage to the plant in developing so early?

Examine the roots of some of the early plants.

Compare the first pair of leaves produced with the later ones.

III. *Some* Spring Flowers.

SKUNK CABBAGE.

Note its habitat, and time of flowering, and answer the following questions:

1. Do leaves or flowers appear first ?
2. Make a drawing of the peculiar flower.
3. Do the stamens and pistils mature at the same time?
4. What insects visit the flower ?
5. What kind of roots has it, and why can it appear so early ?
6. What is the nature of the mature fruit?

JACK-IN-THE-PULPIT.

1. Compare Jack-in-the-Pulpit with Skunk Cabbage. Are these plants related ?
2. What insects visit Jack ? What is his habitat ?

HEPATICA.

Note:

1. Habitat.
2. Color—are all of same color?
3. Fragrance.
4. Insects that visit the flowers.
5. Texture and color of leaves of fall and spring leaves.
6. Buds in the fall.

TRILLIUM.

Note carefully:

1. The habitat or home of the Trillium.
2. The species and their differences.
3. The underground portion.
4. The color, fragrance, and insects.

IV. *Some* Autumn Flowers.

BUTTER-AND-EGGS OR TOADFLAX.

Note where this plant grows and answer the following questions:

1. What insects visit the flowers ?
2. What attracts the insects ? Find where the attracting substance is kept. Is there any marking to guide the insect to the right [illegible] ?
3. Do the stamens and pistils mature at the same time ?
4. What is the nature of the root system, and why is this plant hard to eradicate? Describe and draw the flower and fruit. To what family does it belong ?

SUNFLOWER.

1. Make a daily record of the changes in position of the head with reference to the sun. Do old plants change as readily as young plants?

2. Is the plant affected by other conditions, such as cold, dew, rain, etc ?

3. Study the structure of the head, and locate the involucre, rays, and disk.

4. What difference between the ray and disk florets ? Draw one of each, and name the parts.

5. Do the stamens and pistils mature at the same time ?

6. What insects visit the flowers ?

7. Describe and draw the fruit.

8. To what family does the Sunflower belong? Name other members.

GARDEN NASTURTIUM.

Examine flowers in all stages of maturity, and answer the following questions :

1. Describe the position of the stamens before the pollen is ripe; when the pollen is ripe. Are all the stamens ripe at the same time ?

2. Describe the position and condition of the style with reference to the stamens at different degrees of ripeness.

3. What is the use of the spur ? Are there "guide lines" to the opening of the spur? What is their position?

4. Why does not the flower stand erect?

5. Make drawings of the flower.

[Consult Newell's Outlines of Botany.]

V. The Dandelion.

1. Determine the arrangement of the LEAVES of the Dandelion; what is the purpose of this arrangement? Number and shape of the leaves? Do you see any special adaptations ? What about the leaves of Dandelions growing in long grass? Under boards?

2. Where is the STEM of the Dandelion ? Determine its length and thickness. Account for the circular markings and scars on the stem. What special advantages in such a short stem ?

3. Describe the ROOT of a Dandelion which has been dug up and washed carefully. Account for the development of so many rootlets.

4. To what family of plants does the Dandelion belong ? Why ? Is the Dandelion a highly evolved plant compared with the Buttercup? Why?

5. Where are the flower-buds found ? Their covering and shape ? Have a cluster of Dandelions under observation for a week or more, and determine *when the buds open; when they close; how often a flower will open; how long a period of sunlight is necessary to make them open.*

6. Study the opening of the *bracts* during the flowering period. Of what advantage to the plant is this opening and closing of the bracts ?

7. Determine the changes in the length of the Scape. What purpose is served? Describe the appearance of the flower when opened for the last time.

8. Determine if the stamens mature *before, at the same time, or later than* the stigmas. Make careful drawings of the flower.

9. Study the development of the Seed; describe the changes which take place. Draw a mature seed.

10. Place a long strip of the scape of a Dandelion in a saucer of water. What occurs? Account for the change. Take it out of the water and put it into a solution of salt. What occurs? Why?

[Consult Scott's Nature-Study and the Child.]

VI. The Leaf.

1. Observe the following details of the leaf as it grows on the plant in the field:

(a) The pattern and individual shape, (b) method of overshading and over-reaching other leaves, (c) adaptation for rain, (d) protection against wind, (e) mechanical support, (f) means of defence against insects and fungi, (g) arrangement for bud protection, (h) autumn coloration.

2. Note any adaptation for gathering the rain of: (a) Groundsel (directing water to base), (b) Common Lettuce, (c) Chickweed (line of hairs along the stem, (d) Ash, (e) Labiates, (f) Grasses.

3. Note any adaptation for protection against storms in the leaf of: (a) Ash (observe on a windy day), (b) Mountain Ash, (c) Beech, (d) Poplar.

4. Note any adaptation as to mechanical support in the leaf of: (a) White Catchfly, (b) Bracken, (c) Blackberry (examine cross-section of petiole).

5. Note any adaptation for bud protection in the bud of: (a) Horse-chestnut, (b) Rumex, (c) Wood-sorrel, (d) Verbascum, (e) Goose Grass, (f) Stachys, (g) Hawthorn, (h) Daisy.

6. Make a collection of leaves showing as many forms as possible. Try to identify the different maples and oaks by their leaves.

7. What is a leaf? What is its main function?

VII. Leaf Fall and Autumn Coloration.

1. Note the manner of leaf-fall upon as many shrubs and trees as possible, especially those with compound leaves.

2. Determine how long the leaves remain attached in privet, laurel, and the various evergreens.

3. Determine how the leaf separates from the stem. Section leaves attached to their stems early in autumn and observe the development of the "cleavage plate."

4. What is the economy of leaf-fall ?

5. Keep a record of the dates of (1) the beginning of coloring, (2) the color, and (3) the changes of color of leaves in autumn.

6. What is the probable influence of (1) frost, (2) oblique rays of sun, (3) diminishing water supply, (4) lower temperature, (5) declining activities of leaf, in autumn coloration. Discuss.

7. What new buds have been formed? How are they located with reference to the leaf? How many buds to a leaf?

VIII. Germinating Seeds.

1. Soak seeds of beans, peas, corn, squash, onion for a few hours in water.

2. Observe and draw external appearences, naming the various parts.

3. Compare structure of these seeds.

4. Germinate some of these in moist sand or loose soil, and examine every day for development. Make drawings to show the changes.

5. Determine how the young plants get out of the seed coat in each case.

6. What is the result if the seed is planted upside down?

7. Compare the habits and form of the Cotyledons of the different seeds.

8. As separate problems, determine the influence of warmth, moisture and air on germination, by suitable experiments.

IX. The Scarlet Runner Bean.

1. Compare with the Wild Cucumber and Pumpkin.

2. Germinate about 100 seeds.

3. Make drawings of the various stages in the germination of the seed. Compare the first pair of leaves produced with those that are produced afterwards. Draw them.

4. Its method of using the tendrils.

5. (a) Note the general shape of the tendrils.

(b) Do they grow rapidly? Measure one and see.

(c) Does the tendril always point in the same direction?

(d) Note the direction it moves.

(e) How far does it move, i.e., through how great an angle?

(f) Does it always move in the same plane? or does it move up and down as well as from right to left?

(g) Is there any advantage to the plant in having its tendrils move through an arc in this way?

(h) Hold your fingers so that it will touch a tendril for five minutes. What happens? Use a stick or lead pencil in the same way.

(i) When the finger or stick is removed does the tendril continue to curl up? Why?

(j) Does it ever straighten out again?

(k) Try one of the old tendrils. Cut it loose and see if it will uncurl again. Why will it not?

6. Nail a little stick just out of reach of one of the tendrils and watch what happens.

(a) Does the plant grow straight towards the stick?

(b) Does the plant act the same as if the stick were not there ?

(c) Is there any attraction in the stick for the plant? i.e., has the stick anything to do with making the plant twine around it?

(d) If there is no attraction between the stick and the plant, why is it the tendrils finally attach themselves to the stick?

X. Living Plants at Work.

The following simple experiments should be carried out whenever practicable, and their significance determined:

1. Place some soaked beans between two portions of damp carpet felt or thick blotting paper in a plate. Cover the whole with another plate placed upside down, and leave in a warm place. Examine every day, and observe any changes.

2. When some of the seeds have sprouted, mark off on the root and stem with India ink, commencing at the tip, very short equal spaces. Replace seedlings in the damp paper between the plates. Examine every day.

3. Grow some seedlings in the dark.

4. Tie carefully a piece of moist bladder membrane over the end of the bulb of a thistle tube, fill the bulb and part of the stem with a strong syrup of sugar, and place the whole bulb end down in a jar of water, taking care to have liquids at same level in stem and jar.

5. Scoop cavities in a carrot and sugar beet, dry carefully and fill with dry sugar. Set aside for a day or two.

6. Place thin slices of sugar beet in separate vessels of water and 10 per cent. solution of salt.

7. Place thin slices of red mangel, which have been boiled for a few minutes, in a dish of water.

8. Tie some rubber cloth or oiled paper about the pot in which geranium plant is growing and cover the whole with a glass or bell-jar.

9. Cut a shoot of geranium or begonia and place the cut end in a bottle of water colored with red ink. Leave for a few hours, and determine what parts of the stem are stained. Use a magnifying glass.

10. Place two small potted plants, one on each pan of a balance. Place a bell-jar over one of the plants. Counterpoise. Observe results.

11. After a few hours take off bell-jar, wipe the moisture carefully from inside and replace. Is balance restored? Explain.

12. Tear off a small strip of epidermis from the lower surface of a leaf, place in a glass side, and examine with a microscope. Note the breathing pores, their shape and number.

13. Boil for a few minutes in water some green leaves; remove and immerse in alcohol until bleached. Notice color of solution. Place bleached leaves in tincture of iodine solution. What happens and what does it indicate? Try variegated leaves.

14. Test in the same way some leaves which have been kept in the dark for a few days.

15. Place some water-cress or other water plant in a jar of water and put in a sunny position. Contrive some way of collecting the gas and test it.

16. Place some soaked peas in a tall jar. Cover tightly with a piece of glass. Test the gas in the jar after 24 hours with a burning match. What is it?

17. Cover a potted plant with a bell-jar. Within place a beaker of clear lime-water and leave the whole in a dark room for a few days.

18. Place a potted plant or some seedlings near a window and leave for a few days without disturbing.

19. Observe the attitude of young sunflowers during a bright day. (Consult Atkinson's First Studies of Plant Life).

XII. The Conifers.

1. What Conifers have their dry, thin bud-scales about the base of the leaves?

2. What Conifers have their needles single, but arranged on all sides of the stem? Arranged in two rows on the stem?

3. What Conifer has single, flattened leaves, inclined to turn upward so that the under side of the stem is nearly bare?

4. Determine how the cones of the different species stand; their size; their time of maturing; and when they cast their seeds.

5. Make short descriptions of the Conifers on the College Campus with regard to (1) *their leaves;* (2) *their cones;* (3) *their bark;* (4) *their habit of branching.*

6. Determine the position of the *fertile* and *sterile* flower clusters on the stems of (1) Larch; (2) Juniper; (3) Yew; (4) Arbor Vitae; (5) Pitch Pine; (6) White Pine; (7) Scotch Pine; (8) Austrian Pine; (9) Norway Spruce.

7. Study the young cones and draw them.

8. How can you tell the age of a Conifer? Ascertain how long the leaves remain attached to the twigs of the Conifer.

XIII. The Wood of Coniferous Trees.

1. In cross sections determine (1) whether the heart-wood and sap-wood are of the same color; (2) whether "autumn wood" is of the same color as the "spring wood."

2. Make diagrammatic sketches to illustrate.

3. Study the specimens in the laboratory.

4. Make a key for identification of different coniferous woods.

5. When are "spring wood" and "autumn wood" formed?

XIV. Logs, Lumber, and Knots.

1. Study the end of a large log of hard wood, and determine the areas: bark, wood, and pith. Make a drawing.

2. Where does a tree grow in thickness? Where is the oldest part of the wood?

3. What does each ring represent? Why? Why is the pith sometimes not exactly at the centre?

4. Of what is the bark mainly composed? How does the inside part differ from the outside? What is the use of the bark to the trees?

5. What is the meaning of the numerous fine rays (medullary rays) leading out from the pith? Are all of the same length? Do they extend into the bark?

6. Determine in which direction the wood splits most readily. Explain.

7. When a log is sawed into boards, will the "grain" of the boards differ according to the way the boards have been sawed? Show clearly by specimens and by drawings.

8. How is "quarter-sawed" lumber obtained? Why is it more expensive than other cuts? Why is it admired in furniture?

9. Examine a tree which has lost a branch (by accident or by pruning). What is happening to the cut end of the wound? Any diseased wood? Why does not the new wound-tissue (callus) always completely cover over the wound?

10. When lumber is sawed from a log made from a tree which has been deprived of branches at some stage of its existence, should you expect to find traces of such branches? What are they called in lumber? Explain the formation of "buried" knots.

11. Find out the various processes by which lumber is made up into furniture.

12. Where are the chief lumber regions of Canada? Why has the price of lumber advanced within recent years?

[Consult Percival and Bailey.]

XV. The Apple Twig.

1. Note the rings on main branches and twigs; cause? age of twig?

2. Examine branches of different ages, and compare the markings and buds.

3. From what buds are the longest growths? Why?

4. Observe the short branches with broken ends; what are these called? Why do not these bear fruit every year? What becomes of the buds formed on the spurs not bearing fruit? What is the cause of the broken ends?

5. Find out the following:

(1) Age of the twigs studied.

(2) Number of apples each fruit-spur bore.

(3) The fruit-spurs for next season.

(4) Where the blossoms did not set.

(5) Where the apples fell before maturity.

(6) Where terminal buds were injured, and lateral buds developed into fruit-buds.

(7) Any accidental markings.

(8) The dormant buds.

[Consult Bailey's Lessons with Plants.]

XVI. *Spurs.*

1. Examine and collect twigs of the various orchard and forest trees.

2. Determine the position of the fruit-spurs on the different twigs. Make careful drawings.

3. Write the story of each of the branches.

4. Some trees have few or no spurs and bear almost entirely on long shoots one year old; other trees produce their fruit-buds chiefly on the apex, or on the sides of spurs, the long shoots of the tree bearing only wood-buds the first year; while others bear almost equally on both long shoots and spurs.

Give examples of the three classes given above.

5. How do the red currant and gooseberry bear their fruit-spurs?

6. Determine if possible the age of fruit-spurs in the different trees studied.

7. What is the importance of a knowledge of fruit- spurs to the orchardist?

XVII. Trees.

1. Common Name, Scientific Name, and Family.

2. The tree from a distance in early spring or winter.

(*a*) The contour, habit of growth, or general outline of the tree, whether *pyramidal, spreading and rounded, pillar-like, symmetrical, or one-sided.*

(*b*) The color of the foliage.

3. The tree at close quarters.

(*a*) *Trunk.* Circularity, straight or crooked, or tapering, excurrent deliquescent, indications of disease or decay, size.

(*b*) *Bark.* Rugged or smooth; brown, gray, or silver white; any tendency to peel off in scales or come off; any lichens, moss or fungi.

(*c*) *Branches.* Whether inclined to the stem at an acute or obtuse angle; general difference between upper and lower branches; whether drooping, or have an upward trend or a downward curve; whether the twigs are one-sided, or on both sides of the main branch; whether alternate or opposite.

(*d*) *Twigs.* Whether crooked, rough-barked, indicating slow growth; or straight, smooth-barked, indicating quick growth; study of transverse section of twig, noting bark, wood and pith and annual rings and medullary rays; examine the buds, and note their relative positions, shape, color, scales, rudimentary leaves and flowers; relation of bud arrangement to branching, and the branching to the ultimate form of the tree; study of leaf-scars; study of bud-scale rings and age of the tree.

XVIII. The Woods of Dicotyledonous Trees.

1. The object of this study is the identification of the woods of our common trees. Transverse sections of twigs ½ to ⅔ inch or more should be made, and with the aid of a lens determine (1) whether there is any diffrence in density between the spring and the autumn woods; (2) whether the vessels are distinctly visible or hardly visible; (3) whether the medullary rays are wide and quite visible to the naked eye; (4) the color of the wood and medullary rays.

2. Make diagrammatic sketches to illustrate the difference between the various woods.

3. Study the specimens in the laboratory.

4. Try and make a key by means of which the woods can be identified.

XIX. The Development of the Apple and Cherry.

This involves a study of the ovary and its changes during the formation of the fruit. Sections of different specimens should be made at frequent intervals, and a series of drawings, kept with their accompanying dates.

1. Make longitudinal and transverse sections of the flowers of an apple. Observe the position and extent of the receptacle and the calyx-tube. Such observation should be made every two days.

2. Determine from your studies the formation of the apple,—the part occupied by the calyx, receptacle, and ovary-wall respectively.

3. Cut sections both longitudinal and transverse of the ovary of the cherry from the time the flower fades up to the time the fruit is quite large. Note especially the growth in thickness of the parts of pericarp, viz., the endocarp or "stone," and the mesocarp or "flesh."

XX. The Rose Family.

1. Collect, dry, and mount as many specimens of the Rose family as you can find.

2. Examine carefully the flowers of each, and make longitudinal, vertical sections of each.

3. Make careful drawings of the vertical sections,—the object being to determine the cohesion and adhesion of the parts of the flower.

4. Group all the forms studied into three: the *apple group;* the *strawberry group;* and the *plum group.*

5. Try to determine the relationships of the forms studied.

6. Compare a raspberry with that of a strawberry. Watch their growth after the flower fades.

7. Watch the development of the ovary of a plum when the flower begins to fade. What becomes of the receptacle?

The following forms at least should be studied: apple, plum, strawberry, spiraea, cherry, june-berry, raspberry, wild rose, hawthorn, pear, cinquefoil, barren strawberry, blackberry, mountain ash.

XXI. The Legumes.

Some Special Studies (Spalding):

(*a*) Arrangements for cross-fertilization.

(*b*) Extent to which the production of seeds of RED CLOVER is dependent on the agency of insects.

(*c*) Capacity of the COMMON PEA for self-fertilization.

(*d*) Occurrence of modified leaves, such as tendrils.

(*e*) Morphology of protective structures of various leguminous plants, e.g., spines of locust and honey locust, hairs of desmodium, etc.

(*f*) Sleep movements of Clover, etc.

(*g*) Causes of the wide distribution of the family.

1. Classify the legumes of the farm according to their leaves, noting whether the leaves are (1) PINNATE, ending in tendrils; or (2) PINNATE with two or more pairs of opposite and one single terminal leaflet; or

(3) leaves with three leaflets; or (4) leaves DIGITATE with more than three leaflets.

2. Study the legumes of a farm. Make a list of the forms.

3. Collect and study the various CLOVERS to be found in the Experimental grounds. In what respect does the young seedling Red Clover differ when grown with cereal crops than when grown alone? Is alsike a hybrid, as its scientific name would imply, (*Trifolium hybridum*)?

4. Watch carefully the flowers of *white clover* (*Trifolium repens*), and determine how such flowers are fertilized; what occurs to each flower after fertilization; how the unfertilized ones (old maids) can be told?

5. Which species of clovers are *annuals, biennials, perennials?* Which are upright growers and which are creeping?

6. Compare the *Medicagos* with the Clovers. Is Black Medick a weed?

7. Compare the *Melilots* with the Clovers. Is White Melilot a weed?

8. Contrast the *Peas* and the *Vetches*. Compare their flowers, and note any points of difference between them. What difference in germination? Make drawings.

9. Collect and preserve the tubercles of the various legumes.

XXII. Grass Investigations.

1. Collect samples and bundles of the various wild and cultivated GRASSES.

2. Determine the following regarding each GRASS:

(*a*) The time of Flowering.
(*b*) The height of growth.
(*c*) How it withstands drouth.
(*d*) How it withstands excess of water.
(*e*) How it withstands pasturing.
(*f*) Its palatability.
(*g*) Its roots, habits, whether creeping, or tufted.
(*h*) Its duration, whether annual, biennial, or perennial.

3. Make germination experiments of as many grasses as possible, and study the habits of the seedlings.

4. Collect samples of commercial grass-seed from various seed houses, and determine the *purity and vitality*.

XXIII. Recognition of Grasses by their Leaves.

1. Ascertain how the leaves are folded in the bud, whether (a) simply folded, or (b) rolled. *Poa pratensis* (June Grass) is folded, and *Phleum pratense* (Timothy) is rolled.

2. Ascertain if there are clasping claw-like appendages at the base of the leaf. *Lolium perenne* (Perennial Rye Grass) and *Festuca pratensis* (Meadow Fescue) have such claw-like appendages, while Fox-tail has none.

3. Ascertain the color of the leaf sheaf below ground.

4. Ascertain whether the leaves are cylindrical or flat; narrow or broad, prominently ribbed or not; the color of the veins.

5. Ascertain whether the leaf-sheaths are smooth or hairy; keeled or not.

6. How do fruit-growers control the Codling Worm?

7. Describe and draw a "scabby" apple. What are the objections

8. Make a *key* by means of the characters of the leaves.

XXIV. The Apple as a Host.

Secure specimens of "wormy" and "scabby" apples.

1. How many kinds of apples do you know?

2. Is there a difference in the size of the cores of different apples?

3. Cut crosswise and lengthwise of two apples. Answer the following questions and draw:

   (*a*) How many cells in the core? How many seeds in each cell?

   (*b*) How do the seeds point? Are they attached?

   (*c*) Is the blossom end connected in any way with the core?

   (*d*) From what part of the flower has the apple (fruit) been derived.

4. Write out an account of the work of the Codling Worm. How many broods in a season? How does it spend the winter?. Collect the different stages of this insect.

5. Where did the worm leave the apple?

6. How do fruit-growers control the Codling Worm?

7. Describe and draw a "scabby" apple. What are the objections to scabby apples? Determine how and where infection takes place, and the development of the disease.

8. How do fruit-growers control the "scab"?

9. Make a collection of other enemies of the apple.

XXV. Fruits.

Collect for comparison and study the fruits of most of the common plants in the vicinity.

1. Group them into (1) *dry*, and (2) *fleshy* forms.

2. Group all the dry fruits into (1) Dehiscent, and (2) Indehiscent forms.

3. What is the general name for a dehiscent fruit? What is the pericarp?

4. Group the dehiscent forms into (1) those derived from a simple one-celled ovary, and (2) those derived from a compound several-celled ovary.

5. Examine the indehiscent fruits; determine how they have developed from the ovary, and make out the changes that have taken place while maturing.

6. Group the fleshy fruits into (1) berries, drupes, pomes, hips, haws, and pepos.

7. Study the fruits of the evergreens; compare them.

8. Study the fruits of the ferns, club-mosses, and mosses.

9. Account for the brilliant colors of some of the fruits.

10. Why is unripe fruit usually green?

11. Why are the seeds of many fruits unpleasant to the taste?

12. Why have some fruits a hard coat next the seed?

13. Why are the seeds of some fruits very small?

14. Why are the edible portions of nuts protected by a shell, and unprotected in berries and such fruits?

XXVI. Nuts.

Collect specimens of hazelnuts, beech nuts, chestnuts, hickory nuts, walnuts, and butternuts.

1. Are all of these fruits? Why? Are they dehiscent or indehiscent? Why?

2. In the case of the first three, of what is the "bur" composed? Does it dehisce in all three?

3. In the case of the last three, of what is the "shuck" or "hull" composed? Does it dehisce in all three?

4. How many cells and seeds does each nut contain? In the chestnut, for example, there are sometimes two kernels in a nut. Explain.

5. What change has taken place in the wall of the ovary of each nut in the process of ripening?

6. Give a botanical definition of *nut*. Is the acorn a nut? Is the horse-chestnut a nut?

7. Why are nuts usually dull colored?

8. Why is the edible portion of nuts protected by a shell?

9. How are the nuts distinguished?

10. How are unripe nuts protected while on the tree?

11. Study the common commercial nuts, such as are sold on the market.

XXVII. Dissemination of Seeds.

Make a collection of seeds, and examine carefully. Answer the following questions:

1. Why do so many seeds have special growths attached to them?
2. Arrange and name the seeds collected according to whether they have
    (*a*) Barbs or grappling devices.
    (*b*) Provision for floating on water.
    (*c*) Provision for floating in the air.
    (*d*) Mechanism for ejection.
    (*e*) Juicy parts attractive to animals.
3. Observe carefully and record the special adaptations to distribution possessed by: Witch-hazel, touch-me-not, dandelion, burdock, beggar-ticks, blueweed, white pig-weed, cherry, basswood, sedge, pine, milk-weed, maple, poison ivy.
4. Why are the seeds of most weeds dull colored?
5. What are the main methods of dissemination of weed seeds?
6. What birds are largely instrumental in dissemination of seeds?

[Consult Beal's Seed Dispersal.]

XXVIII. Domestic Animals.

1. Compare the dog, cat, cow, horse, and sheep as to (a) habits of feeding, (b) coverings, (c) shape of limbs, (d) mode of using the limbs, (e) their paws or hoofs, &c., (g) teeth, (h) shape of head.

2. What animal was probably first domesticated or tamed?

3. Study carefully the dog: Kinds—shepherd dog, coach dog, hunter, &c.; as companion or playmate; care of dogs, intelligence, and fidelity; strong senses of hearing and smelling; character of paws and claws; what wild animals are related to the dog?

4. Study the *cat*, comparing it with the dog as to intelligence, form, use, manner of walking, senses, affection, paws, and claws, tongue, bad habits. What wild animals are related to the cat?

5. Study the *cow*: What kind of food does it eat? How does it eat? What is the "cud"? What are *ruminants*? Name some ruminants. Of what use are the horns? What are some of the uses of the living cow? Of the dead cow? How does the cow lie down? Get up?

6. Study the horse: Importance in commerce and war; to civilization; kinds; intelligence; dentition; kind of food, manner of eating; feet, the way the horse lies down and gets up; care of horses; origin; wild horses. What wild animals are closely related to the horse?

XXIX. Animal Movements.

1. Study the way the following animals walk: Horse, cow, cat, dog. In what order are the feet placed in walking? In trotting? In galloping?

2. Study the movements of an earthworm, a clam, an insect.

3. Study the movements of a fish, a snake, and a bird.

4. How does a rabbit run? A robin or a crow walk?

5. To what extent has the need for getting food affected the manner of movement of animals? Study cat and dog.

6. To what extent has the place where food is obtained affected the movement? Study fish, bird, earthworm, clam.

7. To what extent has the need for escape from enemies affected the mode of movement? Study rabbit, squirrel.

XXX. Animal Coverings.

1. Compare the natural covering of man, horse, cow, rabbit, cat, pig, sheep, mink, hen, turtle, snake, frog, fish, caterpillar, and earthworm. Name those covered with hair, with fur, with wool, with feathers, with scales.

2. What is the use of the covering? Does it vary from season to season in different animals?

3. What is the difference between fur, hair, and wool?

4. Where do fur-bearing animals live? Where animals with hair?

5. What is the arrangement of the feathers on a bird? What is the special advantage of feathers as a covering?

6. Compare the winter plumage with the summer plumage of birds.

7. How are the scales of a fish or snake arranged? Of what advantage?

8. What is peculiar about the coverings of insects? How can insects grow with such coverings?

9. Why does a snake shed its skin? How often?

10. To what uses are the coverings of animals put? Specify.

XXXI. Food-Getting Among Animals.

1. Study the ways the horse, cow, sheep, cat, and dog seize their food.

2. What animals use their fore limbs in eating? What do not?

3. What animals are flesh-eaters? What are plant-eaters?

4. Study the dentition of rabbit, cow, horse, sheep, and man. What are the names of the different kinds of teeth and the use of each?

5. Study carefully how the cat eats its food. What other animals eat their food in the same way ? Of what use is the tongue ?

6. How does the dog and cat take liquid food ?

7. What animals get their food at night ?

8. What is the food of the earthworm and how does it take it into its body ?

9. Watch how a snake takes its food, a frog, a caterpillar.

10. To what extent do the kind of food and the food-getting affect the shape of the head and jaws ?

11. Does the food supply affect the habits of animals at different seasons ?

12. Determine whether the following animals are beneficial or injurious: Mole, snake, toad, sparrows, hawks, owls, woodchucks, squirrel, weasel, racoon, rat, mouse, plant-lice.

XXXII. Adaptations Among Animals and Plants.

1. In what particular is the *cat* adapted for (a) securing food, (b) protecting itself, (c) defending its young, (d) in fighting with another cat or other animals, (e) its surroundings ?

2. Study the adaptation of the squirrel, the hawk, the horse, the giraffe, the deer, the mole, to their respective mode of life.

3. Find examples of caterpillars and other insects which are protected by their color. What higher animals are protected in this way ?

4. How are the skunk, the porcupine, the wasp, and the bee protected ?

5. To what extent are fishes, birds, reptiles, and worms adapted to their mode of life ?

6. Find plants that are well adapted to their particular mode of life.

7. What are some of the means plants have of surviving under unfavorable conditions ?

8. Explain how all plants and animals are adapted to their surroundings ?

(Read "Animal Life" by Jordan and Kellogg: Appleton).

XXXIII. Snails and Slugs.

These animals belong to the sub-kingdom Mollusca, (mollis, soft; esca, flesh). Why ?

Slugs have an internal flat shell, while snails have one coiled internal valve.

1. *The Shell.* Find all the different kinds of snails you can. Rest the shell on its base with the aperture pointing toward you, and draw a plan of the spiral. Does the spiral run to the right or to the left ? In a

right handed dextral shell, Helix, Limnaea, in this position the aperture is to the right of the axis. Or imagine such a shell a spiral stair-case, as you ascend, the axis of the spire will always be on your left. Can you find any left-handed (sinistral) shells ? (Physa). All whorls nearly in the same plane, (Planorbis). How many whorls are there in the spiral ? (The largest is the body-whorl, where most of the soft body of the snail is protected, the rest is the spire.)

Observe the lines of growth running parallel with the opening in the shell. Note the color and surface markings. Can you see a few well-marked lines often separating off areas of different depths of color ? These each distinguish one year's growth from another. How old are your specimens ?

Break out a piece of the shell from the edge of the body whorl. Is the gap filled in, or is the new piece of the same color as the rest of the shell ? Try the same experiment again removing parts of shell from the body-whorl, not from the edge but from the spire. How long does reparation require ? Is there any protective coloration ?

2. *Locomotion.* Snails and slugs belong to the class *Gastropoda* (bellyfooted) as foot is on the ventral surface of the body. Let snail crawl on a piece of glass, and watch its movements from the under side with a lens. Do you see a wavelike motion? Which way do the waves move ? Why can snail hold on to a surface so firmly ?

3. *Head.* How many horns on the head ? Describe them. Where are the eyes. Are some of the tentacles more sensitive to touch than others ? Watch mouth and its motions. Observe how it feeds. Can you see tongue (radula) as a Helix rasps off the epidermis of a lea ? (The radula ribbon is covered with thousands of minute sharp teeth).

4. *Respiration.* Observe the opening to the lung on the right side of the body. What movements of the aperture occur ? Will Helix live in water ? Will Limnaea live long totally submerged, and completely deprived of air ?

5. *Food.* Try feeding experiments with Helix, Limax, and Limnaea. Try leaves, dry leaves, soap, dead bodies of snails and slugs, and other species; lichens, mayflies, coleoptera; raw beef, fungi. Will Limax bite your hand ? Try tender skin between fingers.

3. *Regeneration.* Do lost tentacles, eyes, parts of the foot grow out again if cut off ?

XXXIV. The *Sundew.*

1. Observe the habitat and general habit of the sundew.

2. Draw a leaf, showing the tentacles.

3. Grow sundew in shallow wooden dishes containing peat, and kept in a room at a temperature of 70 degrees F.

4. "Place pieces of rotten wood, boiled meat, or boiled egg, or bits of glass no longer than a pin head, on the tips of the glands of the tenacles at the margin of the leaves," and watch the result.

5. How long before movement takes place ? Use a lens.

6. Does relaxation of the movement occur while the object remains on the tentacle ?

7. Do all the objects mentioned secure equal reactions ?

8. How is the amount of secretion influenced by the different objects ?

9. Place a small cube of 1 mm side, with sharply cut edges, of the white of a hard boiled egg on each of several sundew leaves, and determine if the albumen is digested after a day or two.

10. Determine the structure of a tentacle, using a microscope. Observe the spirally thickened wood-fibres, or "water-pipes."

11. Try the action of very dilute solutions of ammonium salts on the bending of the tentacles.

12. Try the action of sugar, starch, dilute alcohol, milk, mucous, and saliva.

13. Are the stalks of the tentacles sensitive ?

14. Repeat Francis Darwin's experiments as to the effect of feeding sundew with roast meat (1-50 grain) on the nutrition and reproduction of the plant.

XXXV. The Wheat Rust.

1. Collect specimens of diseased barberry leaves, and determine when the cluster-cups are mature.

2. Make careful drawings of the cluster-cup.

3. From the mature cluster-cup remove some spores to a moistened leaf seedling of wheat or oat plants.

4. Determine when the rust appears on the wheat or oat leaves after inoculation.

5. Inoculate other wheat plants and other oat plants from the first inoculated plants.

6. Try to get specimens of wheat or oats infested with Black Rust, and which have wintered over in exposed places. Determine how the Black Rust spores germinate.

XXXVI. The Life History of the Toad or Frog.

1. Collect the eggs at the river in early spring. About how many eggs are laid by one toad ? What is the difference between the toad's eggs and the frog's eggs ? Keep the eggs in a flat glass dish in water and watch them hatch. Change the water every two or three days. Draw a few eggs.

2. Draw the tadpole in its various stages of development. Note some of the habits of the tadpole, how it swims, breathes, etc.

3. Test them with various kinds of food.
4. Note the development of the legs.
5. What becomes of the tail ?
6. Examine its eyes. Has it any eye-lids ?
7. Study the habits of the frog.
8. What does it eat ?
9. How does it breathe ?
10. Does it ever drink ?
11. Experiment. Dreprive a toad of water for a day and weigh him carefully. Next sit him on a wet blotting paper for an hour or two and weigh again. What is the increase in weight due to ?
12. Note its humpbacked body and its sitting posture.
13. What are the natural enemies of tadpoles ?
14. What are the natural enemies of the frog ?
15. Since so many eggs are laid by each female frog, and nearly all these produce tadpoles, how do you account for so few frogs ?
16. Of what economic value are toads ?
17. Write a short account of the life history of the toad, and compare with that of the frog.
18. How many kinds of frogs in your vicinity?

XXXVII. Mosquitoes.

1. Collect some larvae of mosquitoes in stagnant water, and place them in a glass jar for observation.

2. Watch carefully the habits of the larvae,—how they breathe, how they swim, and whether heavier or lighter than water.

3. Make drawings of the larvae.

4. How long do the mosquitoes remain in the larval stage?

5. Study carefully the pupa stage,—how it differs from the larval, how it breathes, etc.

6. Watch the escape of the adult mosquito. Describe the operation. What state of water is necessary ?

7. Are all the larvae exactly like ? the pupae ? the adults ? What difference between the male and female ?

8. Secure specimens of Culex, of Anopheles, both males and females.

9. Try simple experiments on the killing of the larvae with oil.

10. Endeavor to get the eggs of mosquitoes. Draw the egg mass.

11. Ascertain the exact duration of the different stages of the mosquito.

XXXVIII. Some Underground Growths.

Collect typical samples of potato tuber, carrot, turnip, and mangel or beet,—

1. Examine the arrangement of the "eyes" on a large potato tuber, and note where they are most numerous.

2. Cut longitudinal and cross sections passing through an "eye." Make drawing, and determine the nature of an "eye." How many buds in an "eye"?

3. What reasons have you for supposing the tuber to be a modified stem? Illustrate by drawings. Locate the cortex, epidermis (periderm), vascular cylinder, cambium ring, and pith. Where is the wood?

4. What is the chief reserve food stored in the tuber? How would you test its presence?

5. Do the true roots rise above or below the tuber-bearing branches in field?

6. What is the advantage of exposing the tubers for planting to light for a week or more?

7. What is generally the shape of the carrot? How are the small secondary roots arranged?

8. Make longitudinal and cross sections of a carrot? Note color, thickness, and texture of the various parts. Draw.

9. Has a carrot a root or a stem structure? Where is the base and the cortex? the wood? the cambium-ring?

10. What is the difference between (1) the root of cultivated and wild forms of carrot, and (2) the first and second year's growth?

11. Make longitudinal and transverse sections of a turnip. Draw. Note color, thickness, and texture of the various parts.

12. Locate bast, cambium and wood. Of what is the wood composed?

13. Make longitudinal and transverse sections of a mangel or beet. Draw; note color, thickness, and texture of the various tissues and soft parenchyma. Which parts are colored? Name the parts as seen in sections.

[Consult Percival's Agricultural Botany.]

XXXIX. Spiders.

Field excursions should be made for the study of the work and habits of spiders. A few spiders may be brought into the class-room and placed in the terrarium, where their habits can often be readily observed.

1. Find *orb-webs, funnel-webs, cob-webs,* and the threads of the *balloon spiders.* Make drawings of the structure of each web, and note where each web is found.

2. Where does the funnel-web spider lie in wait for his prey? What is the appearance of this spider, and what is the structure of the web? Observe and describe the tunnel.

3. How does the orb-web spider or weaver make his web? How many kinds of silk are used? How is the spiral thread arranged? Where does the spider lie in wait for its prey? How does the spider pass from one side of the web to the other?

4. What is the structure of a *cob-web*?
Where and how does the spider lie in wait?

5. Find, and study *jumping spiders, running spiders, ballooning spiders;* harvestmen.

6. Observe how the silk is spun by the spiders.

7. Collect the egg-sacs of spiders, and note where they are found. Determine when the eggs hatch.

8. Compare a spider with an insect. In what respect do they differ?
[Consult Comstock.]

XL. Plant Galls.

Collect the Galls on as many different plants as possible, and make drawings of their shape and contents.

Try and answer the following questions:

1. What galls have openings?

2. What galls are single-celled? Many-celled?

3. What galls become empty before the close of autumn?

4. Find examples of galls on roots and stems.

5. Study carefully the Pine-Cone Willow-Gall, and give a reason for the Cone. Keep some of these Willow-Galls in a jar, covered with cheese cloth, until spring.

6. Put away also some of the Mossy Rose-Galls and Oak-Galls.

7. Classify the galls collected according to the insects producing them. Which were made by aphids? by Hymenoptera (Cynipids)? by Diptera (Cecidomyia)? by moths? by mites?

8. How were the galls made?

9. Compare the galls found on Golden Rod; on Oak; on Maple; on Elm; on Grape; on Witch-hazel; on Poplar; on Hickory; on Rosa; on Rubus.

XLI. Earthworms.

1. Prepare a wooden box with holes on side to admit air; almost fill the box with rich, moist earth, in which are many decaying leaves and stems; place some earthworms on the surface; moisten the earth occasionally.

2. Observe the habits of the worms in the box, how they bore through the earth; why they come to the surface after rain.

3. Examine worm-casts,—their shape, whence they came, and how they are brought to the surface.

4. Determine how a worm crawls,—

5. Examine the front end; does the worm always travel the same end foremost ?

6. Examine the home of the earthworm, using a trowel to remove the layers of earth; what is found in the holes ?

7. Find out the kind of food the worm likes; try different kinds.

8. Are roots of plants eaten by earthworms ? Where are worms most abundant ?

9. Determine the sense-organs of earthworms :

(*a*) Note the quickness with which they retreat when disturbed by a heavy step on the earth near their burrows. What sense has warned them of the approach of danger : seeing, hearing, or feeling ?

(*b*) Note the force with which they cling to their burrows when an attempt is made to drag them out.

How is it they cling so strongly ?

Examine the sides and under surface of the worm for an additional cause.

(*c*) Can they see ? Test by bringing light towards them.

(*d*) Can they hear? Test by yelling close to one or beating a tin pan.

(*e*) Can they smell? Test by hiding a piece of its favorite food which you have already determined by experiment, and note whether it finds it.

10. Determine the general appearance of an earthworm.

11. Find the eggs of earthworms; the sac which contains them.

Watch a rich piece of lawn well, before dusk, and, with lantern in hand, watch carefully the habits of the worms which come to the surface after dark.

XLII. The Songs of Insects.

Collect some crickets, locusts, katydids, meadow grasshoppers, and tree crickets, and place them in a terrarium in which there is some green grass.

1. Determine if both males and females sing.

2. Observe carefully, and determine how each singer makes noise.

3. Find where the "ears" are situated.

4. Try and procure a Cicada, and determine how it makes its peculiar song. Is the singer male or female?

5. What other insects make noises?

XLIII. An Ant's Nest.

Prepare an ant's nest (see Comstock's Insect Life, p. 279).

1. Are all ants' nests alike? In what situations have you found them?

2. Describe a nest.

3. Describe the appearance of the different kinds of ants in a nest. What is the duty of each kind?

4. What are the white bodies seen in the nest?

5. When have you seen winged ants? Try and find an ant ridding itself of its wings.

6. Make a collection of all kinds of ants you have seen.

7. What relationship have you noticed between ants and aphids?

8. What is the best way of ridding a room of ants?

XLIV. The House-Fly.

1. Why are house-flies more abundant in September than in early summer?

2. Watch a fly feed. How does it take its food? As a solid or a liquid? Does it make use of its feet while feeding? How?

3. Determine the structure of its mouth. By pinching a fly's head gently the mouth parts will protrude. Examine with a lens. Draw.

4. Draw the house-fly while it is resting on a piece of paper. Name the parts.

5. Where do house-flies deposit their eggs? Observe the creatures that hatch from the eggs. What are they called? Find the next stage. Preserve these in a box. What are these called?

6. Catch some of the flies that bite before rain. Are these house-flies? Examine carefully, and look at mouth parts.

7. Examine a fly's foot and try to account for its clinging to ceiling.

8. Collect other flies that frequent the house and determine the difference between them and the house-fly.

XLV. The Currant Saw-Fly.

1. Collect, draw and examine the leaves of the currant on which are deposited the eggs of saw-fly.

2. Note the location of the eggs on the leaves.

3. Collect some of the adult insects and pin them in your collection.

4. Determine the duration of (1) egg stage, (2) larval stage, (3) pupal stage.

5. Describe the mode of feeding of the larvae.

XLVI. The Pear Tree Slug.

1. Find some of the eggs, and if possible some of the females ovipositing. What is the shape of the egg?
2. How many eggs to a leaf?
3. Examine larva and its manner of feeding.
4. Its duration as larva. Number of moults.

XLVII. The Spruce Gall-Louse.

1. Examine carefully some infested twigs of white spruce, and determine the shape of galls.
2. Watch for the deposition of eggs in woolly coverings about May 10th.
3. Draw egg masses. Estimate the number of eggs.
4. How long before the eggs hatch?
5. Watch the grey lice for five or six successive days, and determine how the galls are made.
6. What are the best means of combating the gall-lice?

XLVIII. The Oyster-Shell Scale.

1. Collect specimens of twigs infested with Oyster-Shell scale, and determine what stage of its history the insect is passing through.
2. Make careful drawings of the adult and young of this insect.
3. Try to find out how far the young would move from the mother scale before it settles down—about June 1st.
3. Determine if you can the duration of each moult.

XLIX. The Larch Saw-Fly.

1. Search carefully in the soil in the larch grove for dark-brown oval objects, and take them to your room; place them in a box and await developments.
2. Describe carefully the adult saw-flies. Any difference between sexes? Pin several for your collection.
3. Observe the females depositing their eggs. Describe the process. How many eggs in the group? Make a drawing of the eggs in place on the twigs. Account for the bending of the twigs.
4. Determine the duration of the egg stage, the number of moults of the larva, the duration of each moulted stage, and any differences between the different moults. Collect specimens of the different moults for your collection.

L. The Potato Beetle.

1. How does the insect pass the winter? When did you first see the adult?

2. Determine the date of the first appearance of eggs. How many in a cluster? How long to lay the eggs? How long in the egg state before hatching? Color? Collect. Where are the eggs laid?

3. Observe the larva in its different moults, and the duration of each moult. Collect the pupae.

4. Describe the full life-history.

LI. Lady-Bird Beetles.

1. Collect as many kinds of Lady-Birds as you can, taking notes of what they were doing when you collected them.

2. What other insects did you find on the same plant?

3. Collect as many Lady-Bird larvae as you can, and preserve them in vials for reference and study.

4. Identify the Lady-Birds collected by means of Comstock's Manual and other reference works.

5. How are Lady-Birds distinguished from leaf-eaters (Chrysomelids)?

6. Determine where the pupa is formed and how.

7. Of what advantage to the Lady-Birds are their bright colors?

8. Make drawings of the most commonly occurring lady-beetles, showing the variations and marking.

9. What Lady-Birds do you find in the greenhouse in scale-infested plants, or on apple trees infested with Oyster-Shell Bark Lice?

10. What Lady-Birds do you find on trees infested with *aphis?*

LII. Some Common Autumn Insects.

Make a collection of as many members of Orthoptera as possible; classify, and name them.

2. Observe the habits of *cockroaches, long-horned grasshoppers, short-horned grasshoppers,* and *crickets.*

3. Determine where they spend the winter.

4. Describe how the grasshoppers and crickets deposit their eggs.

5. Collect "woolly bears," milkweed caterpillars, dagger caterpillars, tiger caterpillars, fall web-worms, and cabbage worms. Place them in separate boxes and feed them their appropriate leaf-food. Watch carefully from day to day for developments.

LIII. Birds.

In the study of birds the student should determine the following points :

(a) size, (b) color, (c) markings, (d) shape of body, bill, wing, tail and foot, (e) appearance, (f) movements, (g) flight, (h) localities frequented, (i) food, (j) song, (k) ha[illegible] nest, (size, form, material building), (m) eggs, (n) incubation, (o[illegible]ng. Record in a note-book.

1. Keep a bird Calendar, such as the following .

Name of Bird.	When First Seen ?	How many were seen?	When it was next seen?	When did it become common?	When it was last seen?	Is it common or rare?	Does it breed near station?	Remarks.

2. Make a list of birds which pass during the Fall Migration.

3. Study carefully the *English Sparrow.*

(*a*) Describe the appearance. Compare the male and the female.

(*b*) Where do sparows build their nests? Color of eggs?

(*c*) Do you find as many sparrows in the country as in the city?

(*d*) Notice the food habits of sparrows during each of the fall and winter months. What seeds have you seen them eat?

(*e*) Where do sparrows roost? How many in one place at one time?

(*f*) Does the English Sparrow molest any other bird?

(*g*) Is it a friend or a foe?

4. Study carefully the *Common Crow.*

(*a*) Describe the appearance, size, etc.

(*b*) Watch a crow flying. Note the peculiarities of flight.

(*c*) Do crows winter in this district? Find the "crow dormitory," if any.

(*d*) Notice the food habits of crows. What food have you seen crows eating?

(*e*) Describe a crow's nest, and the eggs and nestlings.

(*f*) Compare plumage of young and old crows. Do males and females differ in color?

(*g*) Discuss the intelligence of the crow. Give evidence.

(*h*) Is the crow a friend or a foe?

5. Study carefully the *Woodpeckers.*

(*a*) How many species have you seen? Name them.

(*b*) Describe the appearance of each.

(*c*) Note the holes made by the *Supsucker.* How are they arranged? What is the object of the holes? Is it a friend or a foe?

(*d*) Watch the *Red-headed Woodpecker;* what is the nature of its food?

(*e*) Describe and draw the Red--headed Woodpecker.

(*f*) Compare the *Downy* and *Hairy Woodpeckers.* What is the nature of their food? Are they friends or foes?

(*g*) How do Woodpeckers *drum?* What is the difference between the *tap* and the *drum?*

(*h*) How does the woodpecker use its tail in climbing? What is the arrangement of its toes?

(*i*) Describe the *Flicker.* Cómpare it with the other woodpeckers.

(*j*) Compare the male and female flickers and other woodpeckers as to color and markings.

(*k*) Watch a flicker feeding its young.

(*l*) What woodpeckers are winter birds? Find out when the others come and go.

LIV. The Robin.

1. *Movements.* Describe the movement of the robin on the ground; and its manner of flight. Compare its flight with that of the Swallow, Song Sparrow, Meadow Lark, Red-headed Woodpecker. What are the characteristic movements of the Robin?

2. *Song and Call.* How many different calls can you detect? Imitate them. What is the apparent meaning of each call? At what seasons does the Robin sing? Does it sing at night? When raining?

3. *Color and Shape.* Are the males and females of the same color and size? Are the young of the same color as the old? What parts are dark? Pure black? White? Red? When does the Robin moult? Draw the robin.

4. *Nest and Eggs.* Determine the time occupied in building the nest and in brooding. When does it begin to make a nest ? Where does it build? Of what is the nest built? Is the nest used more than once? How often each season does the Robin brood? How long before the first egg is hatched? What is the number, shape, and color of the eggs? When does the mother bird leave the nest to feed?

5. *Food.* What is the most common food of the Robin? When is the Robin not beneficial? What is the food of the young? Compare the food of the Robin with that of the Bluebird, Wood Thrush, Hairy Woodpecker, etc.

6. *General Questions.* Where do the Robins pass the winter? What is the exact date of leaving your locality? And return? Do the same Robins return every spring to the same localities? Compare the nesting habits of the Robin with those of the other members of the

Thrush family. Do both males and females look after the nest and help to feed the young?

LV. Bird Identification Blank.

Locality ....
Date ....
Haunt ....
Length (tip of bill to end of tail) ....
Size and shape of bill ....
Length and shape of tail ....

COLOR—

Forehead ....
Crown ....
Cheeks ....
Nape ....
Back ....
Rump ....
Upper-tail coverts ....
Tail ....
Wings ....
Throat ....
Breast ....
Abdomen ....

Voice ....
Movements ....
Nest ....
Food ....

Then use the *keys* in Merriam, Hoffman & Walter for identification.

LVI. Red Squirrels.

1. Why are red squirrels not desirable animals to have about home?

2. Find a nest. Has it the same nest for both summer and winter? Of what is it composed ?

3. What is the food of red squirrels ? Watch a squirrel eating. Sketch.

4. Show clearly how the squirrel is well adapted to a life among trees.

5. Examine the mouth of a squirrel, and show how the teeth are well adapted for opening nuts and grinding hard seeds.

6. What enemies have squirrels ? Watch a squirrel in flight. Determine how its passes from tree to tree.

7. Study the calls of the squirrel.

8. What are the uses of the tail ?

9. How does the chipmunk differ in appearance from the red squirrel ? Sketch.

10. Compare the habits of the squirrels.

LVII. Water, Steam, and Ice.

1. Determine the physical properties of water, such as color, taste, shape, surface, and cohesion, by simple experiments. In what respects does water differ from steam or ice ?

2. Describe the effects of heat on water in a glass flask. What is the cause of " singing " just before boiling ? Is steam visible? What is a cloud ?

3. What happens when a jet of steam strikes a cold surface ?

4. What is evaporation ? Why is evaporation more rapid some days than others ?

5. Why do wet clothes dry more rapidly some days than others ?

6. Explain the "sweating of pitchers containing ice-water."

7. Explain the formation of clouds. Why are some clouds white, others black ? Why do clouds move ?

9. How is rain formed ? When clouds rapidly disappear what is the probable reason ?

10. Determine the conditions of formation of ice and snow.

11. Examine snow-flakes and observe their structure.

12. How could you show that water expands on being heated? That water expands on freezing ?

13. What is a thermometer ? What is its use ?

14. Show that heat is required to melt ice.

LVIII. The Air.

1. What are the proofs for the existence of air ? Make experiments.

2. Show that air exerts pressure, is elastic, has weight, expands when warmed, and contracts when cooled (use an air-thermometer to show expansion and contraction).

3. Air is a gas. Name other gases which are also colorless and odorless.

4. Make some carbonic-acid gas and determine its properties. How do its properties differ from those of air ?

5. Why water rises when the piston is drawn up in a " squirt-gun " or syringe.

6. The barometer. Why is mercury used ? What is the use of the barometer ?

7. Winds : Their cause, direction, importance, kinds.

LIX. The Lamp or Candle Flame.

1. What part of the flame gives forth most light? Sketch the flame.

2. By lowering a sheet of white paper upon the flame find at what part the flame is hottest by observing the areas scorched.

3. What is the use of the wick? Is it consumed?

4. Determine all that happens when a fine wire gauze is lowered upon a flame. Explain the phenomena.

5. Have you evidence that there is a gradual conversion of the solid tallow into a liquid, then into gas, before it burns?

6. How can you show that free Carbon is present in the luminous part of the flame? Explain the "smoking" of a lamp or gas jet.

7. How can you show that without air a candle will not burn? Account for the presence of the holes in the base of a lamp-burner.

8. Show that carbon dioxide gas is formed when a candle burns.

LX. A Snow Storm.

1. What causes snow?

2. At what temperature do snow crystals form?

3. How do the clouds appear before a snow storm?

4. What is the temperature of the air before the storm?

5. What is the direction of the wind before the storm?

6. Does the storm come in the same direction as the wind?

7. What are the conditions of the wind and temperature when the snow crystals are most perfect in form?

8. What are these conditions when the snow crystals are matted together in great flakes?

9. What are these conditions when the snow crystals appear sharp and needle-like?

10. Are the snow crystals of the same storm similar in structure and decoration?

11. What is the difference in structure between a snowflake and a hailstone?

12. What is sleet?

13. What is the difference between hoar frost and snow?

14. Does the temperature rise or fall during a snow storm?

15. Is it colder or warmer after a storm has passed than it was before it began?

16. What are the conditions of weather which cause a blizzard?

17. Why does a covering of snow prevent the ground from freezing so severely as it would if bare?

18. Why is snow a bad conductor of heat ?

19. Pack snow in a quart cup until it is full and then let it melt, and tell how full the cup is of water. What do you infer from this?

20. Have you ever observed the grass to be green beneath snow drifts ?

21. Does snow evaporate as well as melt?

22. How does the snow benefit the farmer and the fruit-grower ?

23. Do the snow storms in your locality come from one general direction all winter? (Cornell Home Nature-Study Leaflet).

LXI. A Thunder Storm.

The pupils should have access to a thermometer and a barometer, and should learn to read and to interpret the readings.

1. What is the state of the air before a thunderstorm?

2. How could you tell there was a great deal of water-vapor in the air at such a time ?

3. Is the air near the ground colder or warmer than the upper air ? How can you tell ?

4. Are there currents of air ? In what direction ? Why ?

5. Why should great banks of cumulus clouds appear ?

6. Observe carefully the growth of this bank of clouds. Why is its base flat ?

7. Why does rain fall ? What is the function of the "dust" particles ?

8. Why do hailstones often fall in a thunder storm?

9. Account if you can for the lightning and thunder. At what time of the day do thunder storms usually occur ?

10. Describe the passing away of the storm.

LXII. The Work of Rain.

Visit (1) a loose or sandy bank, and (2) a level field, after a rain storm, and study the work of the rain.

1. Ascertain where the deep furrows are made.

2. What becomes of the constituents of the bank and field when carried away ?

3. What kinds of material are carried farthest by the water ?

4. Examine a rain-pool, and, after it has dried, account for the position of the deposits.

5. Find a delta; study its structure in detail.

LXIII. The Work of Streams.

Determine the following points after a visit to a stream (1) before rain; (2) after rain:

1. Where is the stream most rapid? In shallow or deep places?
2. The carrying power of water of different velocities.
3. The position of *bars* and other obstructions in the channel, and the causes.
4. The cause of variation in width of stream.
5. When banks are worn away, where are the materials deposited?
6. What gives the general direction to the stream?
7. Account for the depth of water at bends, and the causes of bends and windings.
8. When do streams tend to straighten their courses?
9. Account for the difference between a gorge and a wide valley.
10. Account for the presence or absence of water-falls.

LXIV. Soils.

CLASSIFICATIONS OF SOILS:

1. *Loam,* composed of equal parts of sand and clay, with some organic matter.
2. *Sandy Loam,* in which there is more sand than clay.
3. *Clay Loam,* in which there is more clay than sand.
4. *Clay Soil,* composed largely of clay.
5. *Sandy Soil,* composed largely of sand.
6. *Gravelly Soil,* containing many pebbles and small stones.
7. *Humus or Organic Soil,* composed largely of decaying organic matter, such as the black soil of swamps, decayed leaves, wood, earth, etc.

Soils are said to be *light* when sand is predominant, and as *heavy* when clay is in excess. The terms LIGHT and HEAVY do not refer to the actual weight of the soil, but to the stickiness and the amount of resistance it offers to tools of cultivation.

PROPERTIES OF SOILS:

1. *Physical Properties,* the more important being,
   - (*a*) Power to absorb and hold heat.
   - (*b*) Power to absorb and hold moisture.
   - (*c*) Power to absorb and hold gas.
   - (*d*) Power to absorb and hold plant food.

2. *Chemical Properties*, relating to the chemic composition of the soil, and the chemical changes which take place in the soil.

3. *Biological Properties*, relating to the life in the soil.

(*a*) The microscopic plants, Bacteria, which oxidize the materials of the soil.

(*b*) Those organisms which break up or decompose the soil compounds.

(*c*) Those organisms which enrich the soil.

(1) Collect samples of the different kinds of soils mentioned above, and label the samples in bottes or vials.

(2.) Make a map of your farm.

(3.) Locate the different soils on this farm on the map, giving a definite color to each variety of soil.

(4.) To what extent has erosion agents, such as rains, running water, etc., modified the surface of the farm since Glacial Times?

(5.) Collect or find samples of alluvial soils, residual soils.

(6.) Determine the depth of the *humus soil* in the woods; in land which has borne but one crop.

(7.) At what depth do you find the subsoil in the different fields.

(8.) To what extent are the crops of the farm influenced by differences in the soil? Are some fields better adapted for certain crops than other fields.

(9.) Determine the physical properties of the various soils collected as per question I.

LXV. Experiments with Soils.

1. The power of loose soils to retain moisture.
2. The power of compact soils to retain moisture.
3. The rate of rise of capillary water in soils.
4. Relation of texture of soils to germination.
5. Texture of different soils after rain.
6. The conservation of moisture, value of mulches.
7. Mechanical analysis of soils.

LXVI. School Gardens.

For each student: one hoe, one garden rake, one garden line, four corner pegs, two dozen 6-inch plant labels, and a note-book.

1. Special Topics for discussion and investigation:

(*a*) The site and aspect of the garden.

(*b*) The soil and its improvement by spade-work, draining and manuring.

(*c*) The build of a plant.
(*d*) What a plant is made of.
(*e*) How plants are nourished.
(*f*) Sap and its movements.
(*g*) Conditions of healthy growth.
(*h*) Germination, growth, flowering, fruiting, and seeding.
(*i*) Annuals, biennials, and perennials.
(*j*) Evergreen and deciduous trees and shubs.
(*k*) The dependence of plants upon insects.
(*l*) The effect of choosing for seed the larger or smaller samples.
(*m*) The effect of early and late springs on vegetation.

2. Some Arithmetic questions:
(*a*) The garden account.
(*b*) The number of plants to fill a given space.
(*c*) The comparative cost of two plots treated differently.
(*d*) The calculation of the perecentage of sound seeds in a sample for a germination test.
(*e*) The calculation of the loss by insects, by fungi; and the gains by beneficial birds, frogs, and insects.

3. Some Geometry problems:
(*a*) The laying out of the plots by various forms.
(*b*) The construction of plants to scale.
(*c*) The slope of the garden.

4. Drawing in connection with School Gardens:
(*a*) The making of diagrams to illustrate important facts of pla and insect life.
(*b*) Drawings from nature of beautiful flowers and leaves.

5. What to plant:
(*a*) Planting of bulbs, etc., in fall.
(*b*) Planting of vegetable seeds in spring.
(*c*) Planting of flower seeds in spring.
(*d*) Planting of seedling trees.

6. *Preparation of the Bulb Bed.* Select sandy soil, if possible, if clay soil secure drainage; throw out six inches of the soil; work in two inches of manure in the bed; throw back half of top soil and plant bulbs cover with remaining top soil. Cover with straw or leaves to a depth of six inches when crust is frozen. Remove cover gradually in April.

7. *The Planting of Bulbs for Spring.*

Hyacinths—6 inches apart.
Tulips—4 or 5 inches apart.

Narcissus—3 inches apart.

Crocusses and Snowdrops—touching one another, and from 3 to 4 inches deep.

8. *Winter Flowering Bulbs.* Oriental Narcissus and Freesia.

Place Oriental Narcissus bulb in a large bowl, in the bottom of which are some stones; fill with water and place the bowl in a warm, light place.

Place four or five freesia bulbs in a pot containing light soil; put in a warm, light place, and keep them moist.

9. Make a *Calendar* of dates of planting the various vegetable seeds when there is a succession of vegetables through the season.

10. Make a diagram showing the succession of vegetables.

11. What vegetables may be planted in fall?

12. What planting of perennial flowering plants should be done in the fall?

LXVII. Rocks and Stones.

1. *In a Gravel Pit.*

(*a*) Assort the stones collected with respect to (1) shape, (2) material composing them.

(*b*) What kind of stone is most abundant? Why are so many kinds found together?

(*c*) Are any of the stones like the rock found in the rocks underneath, or quarries, in the neighborhood?

(*d*) Account for the presence of so many stones away from a stream; also for the sand layers.

(*e*) What agent, or agents, has given shape to the stones?

(*f*) What evidences that the stones have been placed in their present position by water? Any evidences that water had nothing to do with it?

(*g*) Note the direction of the gravel ridge. Do other gravel ridges of district run in the same direction?

(*h*) What evidence that the ridge has been formed for some time?

(*i*) Compare the surface of stone with that of freshly broken stone. Account for the difference.

(*j*) Account for the coloring of some stones and beds.

2. *On the Surface of the Ground.*

(*a*) Visit a stone-pile in a field. Collect as many kinds as you can.

(*b*) What proportion is rounded? What are the names of the kinds of rocks collected?

(*c*) Compare the surface of exposed and freshly broken rocks.

(*d*) What is the nature of the soil on which the rocks were found?

(*e*) Account for the presence of such stones (boulders).

(*f*) Are they strewn evenly over the field? over the district?

(*g*) Find specimens of rocks which are badly decomposed, and observe the nature of the residue.

3. *In a Quarry or River-bank.*

(*a*) What is the composition of the rock?

(*b*) Are the rocks in layers? Are they horizontal?

(*c*) Are the layers (strata) composed of the same material? Are they of equal thickness? Try and explain the variations.

(*d*) Measure the Dip, and strike off the rocks.

(*e*) Are their fossils in the rocks?

(*f*) Examine the soft material lying above the rock, and determine how it has been formed.

LXVIII. The Surface Features of the District.

(From Jackman's Nature Study.)

1. In looking over the country about you, can you tell what has been the most important agent in its formation?

2. Is the same force still at work? Is it working rapidly or slowly?

3. What other forces have left their impress upon the country? Are they still acting?

4. Are there any evidences as to whether these forces ever worked more rapidly or more powerfully than now?

5. Can you find any place where the land is being torn down? What is doing it? What becomes of the material when torn away?

6. Are there any forces which oppose the tearing away?

LXIX. The Heavens at Night.

1. Determine the position of the *Great Bear*, *Cassiopeia*, *Vega*, and *Capella*, with reference to the North Star or *Polaris*. Observe their apparent rotation about Polaris once every day.

2. Determine the time of rotation of the earth on its axis. Describe the method.

3. Locate the position of: Taurus (Bull), Perseus, Orion, Leo, Virgo, Aries (Ram), Pegasus, and Aquarius,—Northern Crown, Northern Cross, Scorpio, with reference to the Great Bear? Explain why we cannot see Orion and Leo in a summer evening. If possible, locate the position of the constellations in early evening, at midnight, and in early morning, say 3.30. Note the changes.

4. Why does the Great Bear appear in early evening high up in May and low down in the Northern sky in October?

5. Determine roughly the *right ascension* and *declination* of the stars: Arcturus, Aldebaran, Sirius, Rigel, Atair, Antares, Capella, Vega, Castor, Procyon. To what constellation does each belong?

6. What constellations lie in the Milky Way? In the Ecliptic? What constellations are always above the horizon, and therefore visible at night?

7. Determine the real direction the moon travels in the sky with regard to the earth. How many degrees does it travel in 24 hours? How many in 28 days?

8. Locate the planets whenever they become visible and follow their courses. What is an evening star?

(Procure Whittaker's *Planisphere*, and Phillip's *Orrery*, and Whittaker's *Almanac*, and study carefully the movements of constellations and Planets).

LXX. Weather and Weather Observations..

Requisites: Daily weather map issued from Meteorological Observatory, Toronto, thermometer, barometer, wind-gauge, and, if possible, the maximum and minimum thermometer and hygrometer.

1. Study the daily weather-map and understand the construction of *isotherms* and *isobars*. The meaning of a number of concentric isobars.

2. Point out clearly *low pressure* and *high pressure* areas and their significance.

3. By a study of several consecutive weather-maps ascertain if the low pressure area moves. What direction? Why? How far each day? Does it follow a certain route?

4. Does a high pressure area move? In what direction? Why?

5. Examine several maps and determine the direction and velocity of the wind near a low pressure area; near a high pressure area. Can you make a general rule?

6. What effect will the direction have on the temperature of the area? Explain.

Discover if the direction of the wind determines locality of cloudiness and rain. Explain.

7. Make daily observations of the readings of the instruments, and make a record of such observations in a special note-book.

A schedule such as the following is recommended:

METEOROLOGICAL RECORD FOR 190

Time of observation

By

Date	Temperature	Barometer	Direct. of wind	Rainfall	Cloudiness	Humidity	Frost or dew	Sun sets	Moon rises	Moon's Phase

8. Make weekly, monthly, or yearly *graphs* of the temperature, barometer, rainfall, etc.

LXXI. Some Farm Operations.

1. What system of rotation is practised on your farm? What is the advantage of a rotation? Why is it necessary?

2. What is a soiling crop? What plants may be used for soiling crops? What are the advantages of each?

3. What is a cover crop? What plants may be used for cover crops?

4. Explain the construction of a silo. What is its use? How and when is it filled? How is the silage used as feed?

5. What is the order of *seeding* in the spring? Why? What advantage in fall plowing?

6. How is the land *prepared* for seeding? The reason for the thorough cultivation? What implements are used?

7. What are the uses of drains? How are they made? When may the drains be made deep? When shallow?

8. What is hay? How cured and why? What plants are grown for hay? What machinery is used in haying?

9. When are grain crops ready to harvest? Why leave the sheaves out in *stooks* for a few days? Describe the operation of threshing. What machinery is used?

10. What advantages arise from cultivating stubble land after harvest? How to rid a badly infested field with weeds?

11. When are clover and timothy sown? Why at that time and with that crop? Why should clean seed only be used? What is meant by *seeding down*?

12. What are the uses of root crops? When and how is the land prepared for corn, for mangels, for turnips? How is each crop harvested?

13. *What is a balanced ration?* Is the ration the same for different animals?

14. Make plans for a stable suited to a 100-acre farm,—general farming.

15. What are the daily operations on your farm in winter?

16. Why should manure be cared for? When should it be applied to the land? What constituent taken from the soil is the most costly to replace? How is it replaced?

17. When and how should the orchard be sprayed? Describe the operations of preparing the solutions and applying them. Why should there be cleanliness about an orchard?

18. When should pruning be done? Why should it be done carefully? Should an orchard be cultivated and fertilized? When?

19. Describe the process of harvesting, of shipping, and of storing fruit.

20. How should milk be cared for? What need for cleanliness? For cooling? For kindness to milch cows? What are the distinguishing characters of a good milch cow? What breeds are the best milk producing breeds? How many pounds of milk should a profitable dairy cow give per year?

Some of the Most Helpful Books in Nature Study.

I. PLANTS.

1.	Lessons with Plants	Bailey ; MacMillan & Co.	$1.25
2.	Plants	Coulter ; Appleton & Co.	1.80
3.	First Studies in Plant Life	Atkinson ; Ginn & Co.	.75
4.	Elementary Botany	Bailey ; MacMillan & Co.	1.00
5.	Agricultural Botany	Percival ; Holt & Co.	1.75
6.	Reader and Outlines in Botany	Newell, 4 vols. ; Ginn & Co.	1.70
7.	Seed Dispersal	Beal ; Ginn & Co.	.40
8.	Sylvan Ontario	Muldrew ; Briggs	.50
9.	How to Make School Gardens	Hemenway ; Doubleday, Page & Co	1.00

II. ANIMALS.

1.	Animal Life	Jordan & Kellogg ; Appleton & Co	1.10
2.	Animal Forms	Jordan & Heath; Appleton & Co.	1.20
3.	Story of the Fishes	Basket ; Appleton & Co.	.65
4.	Wild Neighbors	Ingersoll ; Harper & Bros.	1.50
5.	Squirrels and Other Fur Bearers	Burroughs ; Houghton, Mifflin & Co	1.20
6.	Birds of Village and Field	Merriam ; Houghton, Mifflin & Co	2.00
7.	Bird Life	Chapman ; Appleton & Co.	3.00
8.	Story of the Birds	Basket ; Appleton & Co.	.65
9.	Manual for the Study of Insects	Comstock ; Comstock Publ. Co., Ithaca, N. Y.	3.75
10.	Insect Life	Comstock ; Appleton & Co.	1.75
11.	Stories of Insect Life	Weed ; Ginn & Co.	.35
12.	The Bee People	Morley ; McClurg & Co.	1.25
13.	The Butterfly Book	Holland ; Doubleday, Page & Co.	3.00
14.	The Moth Book	Holland ; Doubleday, Page & Co.	4.00
15.	The Insect Book	Howard ; Doubleday, Page & Co.	3.00
16.	How to Name the Butterflies	Comstock ; Appleton & Co.	2.50
17.	The Birds of New England	Hoffman ; Houghton, Mifflin & Co.	1.60
18.	Wild Birds in City Parks	Walter ; Mumford, Chicago	.50

III. PHYSICAL GEOGRAPHY AND GEOLOGY.

1.	Elementary Geology	Tarr ; MacMillan & Co.	$1.40
2.	Elementary Physical Geography	Gilbert & Brigham ; Appleton & Co.	1.40
3.	Elementary Geology	Brigham ; Appleton & Co.	1.40
4.	Physical Geography	Dryer ; American Book Co.	1.25
5.	H. S. Geography	Chase ; Can. Pub. Co.	1.00
6.	Modern Geography	Morang	.75
7.	Child and Nature	Frye ; Ginn & Co.	.80

IV. CHEMISTRY AND PHYSICS.

1.	Simple Experiments for the Schoolroom	Woodhull ; Kellogg & Co., N.Y.	.50
2.	Elementary Physics and Chemistry	Gregory & Simmons; MacMillan & Co.	.50

V. NATURE STUDY.

1.	Nature Study and the Child	Scott; D. C. Heath	1.50
2.	Nature Study and Life	Hodge; Ginn & Co.	1.50
3.	Guide to Nature Study	Crawford; Copp, Clark Co.	.90
4.	Modern Nature Study	Silcox & Stevenson; Morang	1.00
5.	Nature Study for Common Schools	Jackman; Holt & Co.	1.20
6.	The Nature Study Idea	Bailey; Doubleday, Page & Co.	1.00
7.	Public School Nature Study	Crawford, and others; Copp, Clark Co.	.50

VI. NATURE READERS.

Friends Worth Knowing	Ingersoll; Harper & Bros.	1.00
Ways of Wood Folk	W. J. Long; Ginn & Co.	.65
Wilderness Ways	W. J. Long; Ginn & Co.	.65
Wild Animals I Have Known	Seton-Thompson; Scribner	2.00
Lives of the Hunted	Seton-Thompson; Scribner	2.00
Nature Pictures	American Poets; MacMillan & Co.	1.25
Poetry of the Seasons	Lovejoy; Silver, Burdett & Co.	.60
Nature in Verse	Lovejoy; Silver, Burdett & Co.	.60
Little Wanderers	Morley; Ginn & Co.	.35
Flowers and Their Friends	Morley; Ginn & Co.	.60

Nature Study or Stories in Agriculture	Staff O. A. C.	
Nature Study Bulletins and Leaflets (Cornell)	Humphrey, Geneva	$1.00
Songs of Nature	Burroughs; McClure, Phillip & Co.	1.00
Nature Biographies	Weed; Doubleday, Page & Co.	
Flashlights from Nature	Grant-Allen; Briggs	
Nature's Garden	Blanchan; Doubleday, Page & Co.	
The Study of Animal Life	Thomson; Murray	
Wild Life Near Home	Sharp; The Century Co.	
A Hermit's Wild Friends	Walton; Dana, Estes & Co.	1.50
Wake Robin, Birds and Poets, Locusts and Wild Honey, Winter Sunshine	Burroughs; D. Douglas	1.00

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